Abstracts

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Ki no Himitsu (Wood, What!), ed. by Wood Research Institute, Kyoto University, May 1994, Tokyo Shoseki Co. Ltd., Tokyo (in Japanese).

This book was edited by Wood Research Institute, Kyoto University in commemoration of the 50th Anniversary of the Institute. Recent topics and progress in the fields of wood science and technology was introduced by all the research staffs of the institute. The titles and the authors are as follows:

The toughness of wood, T. ITOH.

The live activity of trees, which produce wood timber, K. BABA.

Diversification of a life style into trees or herbs, H. KURODA.

Growth of bamboo, T. NOMURA.

The walls of growing plant cells, T. HAYASHI.

Introduction of foreign genes of woody plants, F. SAKAI.

Trunk forming genes, H. KURODA.

Chirality in wood science, T. UMEZAWA.

Producing energy from wood, M. KUWAHARA.

Celluloses sustain trees, J. SUGIYAMA.

Production of foodstuffs from woody biomass, T. WATANABE.

Cellulose plastics, T. MOROOKA.

An outlook over the molecular world in woody plant, F. TANAKA.

Utilization of wood, E. MAEKAWA.

Large deformation of wood and processing, M. NORIMOTO.

Wood material science —The science for saving the earth—, H. SASAKI.

New wood-based materials —Engineered wood—, S. KAWAI.

Board that can not be said a solid board, T. HATA.

Theory and technology of liquid impregnation into wood, Y. IMAMURA.

The higher performance of carbon composites, the higher temperature carbonization of wood, S. ISHIHARA.

Wood enhanced in the resistance against fungi and termite, M. TAKAHASHI.

Intending to structural design of durable residence, S. TAKINO.

Wooden houses in various structures, N. ANDO.

Why is wood degraded?, M. TAKAHASHI.

A wooden house is endangered by oxalic acid produced brown-rot mushrooms, M. SHIMADA.

The 'wonderful' mushrooms, Y. HONDA.

Lignin degrading enzymes, T. UMEZAWA and T. HATTORI.

Mysterious world of wood-eating insects, T. YOSHIMURA.

Marine wood-boring bivalve, K. TSUNODA.

Detection of the biological degradation in wood by acoustic methods, Y. IMAMURA.

Determination of nucleotide sequence of a region producing multiple polygalacturonases from *Erwinia carotovora* subsp. *carotovora* EC1, J. JHONCON, F. SAKAI and S. TSUYUMU: *Ann. Phytopath. Soc. Japan,* **60**, 208–215 (1994).

DNA region consists of 1804 bases (b) was shown to produce four polygalacturonases (Peh) in *Erwinia carotovora* subsp. *carotovora* (E.c.c.) EC1. The sequence of this region was determined in both directions. In this DNA fragment, there was one open reading frame (ORF1) that encodes for protein of 402 amino acids with a calculated molecular weight of 42,646 which is in the range of previously reported molecular weight of E.c.c. Peh. The sequence of the amino acids deduced from ORF1 showed 90% homology with that of reported E.c.c. Peh. A possible signal peptide of 26 amino acids was found. Several shorter ORF were also found from both strands. Possible role of remaining 595 b for the production of four Peh was discussed.

Purification and properties of extracellular endo-1,4-β-glucanase from suspension-cultured poplar cells, S. NAKAMURA and T. HAYASHI: *Plant Cell Physiol.,* **34**, 1009–1013 (1993).

An endo-1, 4-β-glucanase (EC 3.2.1.4) was purified to apparent homogeneity from the culture medium of poplar (*Populus alba* L.) cells by sequential anion-exchange, hydrophobic, and gel-filtration chromatography. The preparation of extracellular β-glucanase was homogeneous on SDS-polyacrylamide gel electrophoresis (PAGE) and native PAGE. The molecular weight, as determined by SDS-PAGE was 50,000, whereas that determined by gel filtration was 40,000. The isoelectric point (pI) was 5.5. The purified enzyme catalyzed the endohydrolysis of carboxymethylcellulose with a pH optimum of 6.0 and a K_m of 1.0 mg ml^{-1}. The enzyme specifically cleaved the 1,4-β-glucosyl linkages of carboxymethylcellulose, swollen cellulose, lichenan and xyloglucan, although the last was hydrolyzed more slowly than the other tested substrates. The activity of the endo-1, 4-β-glucanase increased up to the early stage of the mid-logarithmic phase of growth and then decreased rapidly, suggesting that the β-glucanase is induced before cell development.

Occurrence of endo-1,4-β-glucanase activities in suspension-cultured poplar cells during growth, S. NAKAMURA and T. HAYASHI: *Mokuzai Gakkaishi,* **39**, 1056–1061 (1993).

Suspension-cultured poplar (*Populus alba* L.) cells generate endo-1,4-β-glucanase activity which catalyzes carboxymethylcellulose with endo-fashion. The activity was associated mainly with cells; part of the activity was soluble, and the rest was buffer-

insoluble but extractable with large salt concentrations from wall preparations. The activity in both buffer-soluble and buffer-insoluble fractions increased to the stationary growth stage and then decreased gradually. When auxin starved cells were cultured in a medium containing 2, 4-dichlorophenoxyacetic acid, the activity increased markedly at the mid-log growth stage, but less activity occurred in cells without auxin. Then the activity decreased rapidly in the buffer-soluble fraction as the growth rate deceased but was maintained in the buffer-insoluble fraction. The activity of endo-1, 4-β-glucanase secreted into the extracellular culture medium increased markedly up to the mid-log growth phase and then disappeared in the stationary growth phase. The level of the activity in the auxin-starved cells was enhanced much more with 2, 4-dichlorophenoxyacetic acid in the culture medium than that associated with cells. These findings suggest that suspension-cultured poplar cells require auxin concomitant with endo-1, 4-β-glucanase activity. Xyloglucan which is a potential substrate for β-glucanase was solubilized in the extracellular culture medium during exponential growth.

Production of endo-1, 4-β-glucanase activity: A simple method for suspension culture of poplar cells, S. NAKAMURA and T. HAYASHI: *Biosci. Biotech. Biochem.*, **57**, 1933–1934 (1993).

A large amount of growing poplar cells and a high level of endo-1, 4-β-glucanase activities have been produced by using a simple and inexpensive system. This system is useful for obtaining not only plant enzymes but also secondary metabolites from the cultured cells of higher plants.

Cell aggregation in suspension-cultured rice cells. II. Involvement of ferulolyl-polysaccharides, Y. KATO, H. YAMANOUCHI, K. HINATA, C. OHSUMI and T. HAYASHI: *Plant Physiol.*, **103**, 1555–1559 (1993).

Fluorescence microscopy of rice (*Oryza satiza* L.) callus sections showed that all of the walls fluoresced blue in water (pH 5.8) and green in ammonia (pH 10.0), both characteristics of feruloyl esters. Such fluorescence in the walls of cells cultured in Gamborg's B5 medium was much stronger than that in amino acid (AA) medium. Laser scanning microscopy showed that the level of fluorescence was higher in the intercellular layer, especially at corner junctions between cells, suggesting that ferulic acid ester derivatives are located in the middle lamella as well as in the wall. Extracellular polysaccharides appearing during cultivation in AA medium were more highly feruloylated than those in B5 medium during cultivation. Both the levels of ferulic and diferulic acid and the relative proportion of diferulic acid in the walls of cells increased on transfer of the cells cultured in AA medium to B5 medium. The walls of cells cultured in B5 medium maintained constant levels and proportions of the phenolic acids. Removal of phenolic acids from wall preparations by carboxylesterase facilitated the solubilization of

noncellulosic polysaccharides. Treatment of the cell aggregates grown in AA medium with an enzyme that hydrolyzes feruloyl esters decreased the size of the aggregates to between 20 and 500 μm, compared with an original sizen between 200 and 1,000 μm. These findings suggest that feruloyl and diferuloyl esters between polysaccharides are involved in the aggregation of cultured rice cells.

An unambiguous nomenclature for xyloglucan-derived oligosaccharides, S.C. FRY, W.S. YORK, P. ALBERSHEIM, A. DARVILL, T. HAYASHI, J.P. JOSELEAU, Y. KATO, E.P. LORENCES, G.A. MACLACHLAN, M. MCNEIL, A. MORT, J.S.G. REID, H.U. SEITZ, R.R. SELVENDRAN, A.G.J. VORAGEN and A.R. WHITE: *Physiol. Plant.*, **89**, 1–3 (1993).

A revised system of abbreviated names is proposed for xyloglucan-derived oligosaccharides. Each (1→4)-linked β-D-glucosyl risidue (and the reducing terminal D-glucose moiety) of the backbone is given a one-letter code according to its substituents. The name of the oligosaccharide consists of these code letters listed in sequence from non-reducing to reducing termines of the backbone.

Volatile flavor components formed in an interspecific hybrid between onion and garlic, C. OHSUMI, T. HAYASHI, K. KUBOTA and A. KOBAYASHI: *J. Agric. Food Chem.*, **41**, 1808–1810 (1993).

Volatile flavor compounds formed in an interspecific hybrid between onion (*Allium cepa* L.) and garlic (*Allium sativum* L.) were examined by GC and GC-MS analysis of headspqce gas with a purge-and-trap injector. The cruched hybrid bulb formed various flavors including both species-specific and new types. The species-specific flavors were identified as thiopropanal S-oxide, which is the major specific flavor and lachrymatory factor in onion, and allyl methyl disulfide and diallyl disulfide, which are major flavors in garlic. The hybrid was thus recohnized to be a new plant from the gas chromatographic patterns, which indicated a combination of the species-specific flavors of both parents.

Effects of amino acid medium on cell aggregation in suspension-cultured rice cells, T. HAYASHI, C. OHSUMI, Y. KATO, H. YAMANOUCHI, K. TORIYAMA and K. HINATA: *Biosci. Biotech. Biochem.*, **58**, 256–260 (1994).

The effects of amino acid medium (AA medium) on the dissociation of rice callus tissues were examined in suspension-cultured cells, because a finely dispersed cell suspension had been obtained previously from rice callus tissues in this medium. The level of extracellular polysaccharides formed in cultured AA medium was much higher than that of those formed in cultured B5 medium. The polysaccharides were mainly composed of higher levels of arabinose, xylose, and galactose, suggesting the solubilization of arabinoxylan and (arabino) galactan. Nevertheless, wall polysaccharides in cells cultured in AA medium contained the same levels of arabinosyl-, xylosel-, and galactosyl-linkages as those in B5 medium. Based

on amino acid analysis, rice cells in AA medium incorporated the amino acids in 3 days and formed ornithine and urea during the early stages of cultivation, and secreted urea into the culture medium. Transfer of rice tissue cultured in AA medium to B5 medium composed of inorganic nitrogen source caused most of the tissue aggregates to become larger than 1,000 μm. However, after tramsfer tp B5, medium containing 1mM arginine, they were apparently maintained as a more-finely dispersed cell suspension at a size below 1,000 μm. These findings suggest that arginine is metabolized in rice cells to form urea, which is then secreted and may solubilize the arabinoxylan and (arabino) galactan between cells. The test of binding capacity confirmed that arabinoxylan was bound to both insoluble xyloglucan and cellulose, and that urea dissociated arabinoxylan from the complex.

Carbohydrate analysis of an interspecific hybrid between onion and garlic, C. OHSUMI and T. HAYASHI: *Biosci. Biotech. Biochem.*, **58**, 959–960 (1994).

Carbohydrates from the bulb tissues of a hybrid between onion (*Allium cepa*) and garlic *(Allium sativum)* were fractionated into 70% ethanol-soluble and insoluble fractions. The substantial soluble fraction comprised a range of fructans, and the insoluble fraction contained large amounts of pectic substances (including 4-linked galactan) and highly branched xyloglucan, which is characteristic of dicotyledons rather than of monocotyledons in the cell-wall composition. The carbohydrates from the hybrid showed characteristics intermediate between onion and garlic.

Localization of xyloglucan in the macromolecular complex composed of xyloglucan and cellulose in pea stems, K. BABA, Y. SONE, A. MISAKI and T. HAYASHI: *Plant Cell Physiol.*, **35**, 439–444 (1994).

A macromolecular complex composed of xyloglucan and cellulose was isolated from elongating regions of stems of etiolated pea (*Pisum sativum* L. var Alaska) seedlings and binding of a xylogucan-specific antibody was examined after treatment of the complex with endo-1, 4-β-glucanase or 24% KOH. The antibody bound to the complex but the extent of binding was reduced after treatment of the complex with endo-1, 4-β-glucanase and was hardly detectable after treatment with 24% KOH. The molecular weight of the xyloglucan that remained (5%) in the β-glucanase-treated complexes was less than 9,200. Pea xyloglucan was allowed to bind to enzymeand alkali-treated complexes to generaly reconstituted complexes. The amount of the antibody that bound to each type of reconstituted complex was similar but was much lower than that bound to the native complex. Immunogold labeling indicated that most of the antigen was widely distributed between microfibrils in the native complex, whereas the antigen appeared to be confined to the microfibrils in the reconstituted complexes. These findings suggest that a part of each xyloglucan molecule is strongly associated with cellulose microfibrils while the rest is free of the microfibrils in the native complex.

Macromolecullar complexes of xyloglucan and cellulose obtained by annealing, T. HAYASHI, K. BABA and K. OGAWA: *Plant Cell Physiol.*, **35**, 219–223 (1994).

Macromolecular complexes composed of xyloglucen and cellulose were produced by heating amorphous celluloses with xyloglucan in water at teperatures above 160°C had a somewhat fiber-like appearance even though mixtures of amorphous celluloses and xyloglucan were sompletely amorphous before annealing. Annealing occurs specifically between amorphous celluloses at high temperatures, where xyloglucan may be entrapped into the bundles of cellulose fibers during fiber formation rather than bound to the surface of fibers.

Endo-1, 4-β-glucanase in the cell wall of stems of auxin-treated pea seedlings, T. HAYASHI and C. OHSUMI: *Plant Cell Physiol.*, **35**, 419–424 (1994).

Endo-1, 4-β-glucanase induced by treatment of pea seedlings with 2, 4-D was extracted from a preparation fo the walls of epicoty cells. The β-glucanase was purified by chromatography on DEAE-cellulose, affinity chromatography on Con A-Sepharose and SDS-polyacrylamide gel electrophoresis (SDS-PAGE). The activity of β-glucanase was retained after removal of SDS and extraction from polyacrylamide gels. The band of a protein (46-kDa), that corresponded to the activity of endo-1, 4-β-glucanase, was injected directly into mice for preparation of antiserum and the protein was also subjected to amino acid sequencing after blotting onto a membrane. Western blot analysis showed that tha antiserum obtained bound to a 46-kDa polypeptide and recognized endo-1, 4-β-glucanase. The N-terminal sequence of the 46-kDa polypeptide revealed some homology to abscission endo-1, 4-β-glucanases of bean and avocado fruit.

Biosynthesis of cellulose in higher plants, T. HAYASHI: *Chemistry and Biology*, **31**, 633–635 (1993) (Japanese).

The review focuses on the biosynthesis of cellulose in higher plants.

Biosynthesis of cell wall polysaccharides and regulation of transferases in woody plants, T. HAYASHI: "Woody Molecular Biology" ed. T. Higuchi, pp. 87–101, Buneido, Tokyo (1994).

The review focuses on the biochemistry of cell wall polysaccharides and the regulation of transferases in woody plants.

Endo-1, 4-β-glucanase in the walls of auxin-treated pea stems, T. HAYASHI and C. OHSUMI: "Genetics, Biochemistry and Ecology of Lignocellulose degradation", K. Shimada et al. eds., Uni Publishers Co., Ltd., Tokyo (1994).

Endo-1, 4-β-glucanase induced by 2, 4-dichlorophenoxyacetic acid was purified from the wall preparation of pea epicotyl cells. The protein band (46 kd), which corresponded to the activity of endo-1, 4-β-glucanase, was injected directly into mouse for antiserum

preparation and was also subjected to the sequencing after blotting onto a membrane. The N-terminal sequence of the 46 kd polypeptide indicated relatedness to not only plant endo-1, 4-β-glucanases but also bacterial endo-1, 4-β-glucanases.

Phenylpropanoid derivatives, H. KURODA and T. HIGUCHI : "Molecular Biology in the Formation and Biodegradation of Wood", ed. T. Higuchi, pp. 109–140, Bun-eido Publishing Co. Ltd, Tokyo, (1994) (in Japanese).

This article reviews recent progresses in shikimate pathway, general phenylpropanoid pathway, and lignin biosynthesis. The cited references cover papers contributed to the progress before the summer in 1993. It especially focuses on enzyme systems and the encoded genes, which are involved in those pathways.

Characterization of antiviral water-soluble lignin from bagasse degraded by *Lentinus edodes*, J.KAJIHARA, T. HATTORI, H. SHIRONO and M. SHIMADA : *Holzforschung,* **47**, 479–485 (1993).

Antiviral water-soluble lignin complex (WSLC) was obtained by purification of extracts from the bagasse culture medium of *Lentinus edodes*. WSLC contained 80% of water-soluble lignin (WSL), 20% of carbohydrates and 1–2% of proteins, but the antiviral activity was demonstrated to be derived from the WSL moiety.

We used WSLC to analyze the structure of WSL in detail in comparison with that of native bagasse milled wood lignin (MWL). The result of nitrobenzene oxidation revealed that the total yield of benzaldehydes originating from WSL was much lower than that from MWL, which suggests that the structure of native bagasse lignin is heavily modified during the decay process. The potassium permanganate oxidation yielded more condensed type products from WSL than from MWL. However the total yields of aromatic acids from WSL were obviously lower than those from MWL. Furthermore, the methoxyl content of WSL was lower than that of MWL. Thus, our results showed that the quantities of benzene rings in WSL were obviously reduced. The decrease in amounts of aromatic moieties in WSL suggests that native aromatic ring structures of bagasse lignin were modified by ring opening or formation of quinone moieties during the degradation of bagasse lignin by *Lentinus edodes*.

Formate and oxalate esters in lignin obtained from bagasse degraded by *Lentinus edodes*, T. HATTORI, J. KAJIHARA, H. SHIRONO, Y. YAMAMOTO and M. SHIMADA : *Mokuzai Gakkaishi,* **39**(11), 1317–1321 (1993).

Antiviral water-soluble lignin complex (WSLC) was purified from the bagasse culture medium of *Lentinus edodes* (Berk.) Sing. The chemical structure of the modified aromatic ring by *L. edodes*. in WSLC was characterized by analyses of the products obtained by the treatment of WSLC with 1 N NaOH for 24 h at room temperature. Seven carboxylic acids

liberated were identified as *p*-hydroxybenzoic, vanillic, syringic, *p*-coumaric, acetic, formic, and oxalic acids. Formic and oxalic acids were found from only WSLC, and five other acids were obtained from both bagasse milled wood lignin (MWL) and WSLC, indicating that formate and oxalate esters occurred in only WSLC. The result suggested that these esters were formed as the result of the aromatic ring opening reaction during the white-rot decay process *L. edodes*.

Biochemical mechanisms for the biodegradation, M. SHIMADA : "Recent Research on Wood and Wood-Based Materials, Current Japanese Materials Research, Vol. **11**" N. Shiraishi, H. Kajita and M. Norimoto, eds., p. 207–222, Elsevier Applied Science, London and New York, 1993.

The biochemical mechanisms for the biodegradation of wood by white-rot and brown-rot fungi are discussed on the basis of recently reported findings. The white-rot wood decay process comprises the enzymatic hydrolysis of cellulose and oxidative breakdown of lignin ; the one-electron oxidation mechanism involved in the intial oxidation of lignin is described. In the enzymatic breakdown of lignin, a cation radical intermediate plays a key role. In the brown-rot wood decay process, cellulose degradation is more critical than that of lignin, and the possible role of Fenton's system, which has been receiving keen attention recently, is discussed in relation to the oxidative breakdown of cellulose. As an alternative hypothesis, however, the possible role of oxalic acid in the hydrolytic cleavage of the cellulose chain is proposed, because oxalic acid is one of the strongest physiological organic acids, and is commonly known as a peculiar secondary metabolite produced by brown-rot fungi.

Oxalic acid metabolism of wood-destroying basidiomycetes ; Toward biochemistry of wood protection, M. SHIMADA : *Wood Research and Technical Notes*, No. **29**, 1–18 (1993) (Review in Japanese).

Biochemical role of oxalic acid produced by white-rot and brown-rot fungi has been discussed in relation to lignin and cellulose degradation during wood decays.

A proposed role of oxalic acid in wood decay systems of wood-rotting basidiomycetes, M. SHIMADA, D. MA, Y. AKAMATSU and T. HATTORI : *FEMS Microbiology Reviews*, **13**, 285–296 (1994).

The possible roles of oxalic acid, veratryl alcohol, and manganese were investigated in relation to lignin biodegradation by white-rot basidiomycetes. Oxalate inhibited both lignin peroxidase (LiP) and manganese-peroxidase (MnP), and decarboxylated by the mediation of veratryl alcohol and Mn. Oxalate was shown to regulate the mineralization of lignin in the in vivo system of *Phanerochaete chrysosporium*. In the brown-rot wood decay process, oxalic acid may serve as an acid catalyst as well as an electron donor for the Fenton reaction, to breakdown cellulose and hemicellulose. Oxaloacetase and glyoxylate oxidase may play a key role in production of oxalic acid by white-rot and brown-rot basidiomycetes

such as *Phanerochaete chrysosporium, Coriolus versicolor* and *Tyromyces palustris*. A possible role of oxalate metabolism is discussed in relation to the physiology of wood-rotting fungi.

Enantioselective lignan synthesis by cell-free extracts of *Forsythia koreana*, T. UMEZAWA, H. KURODA, T. ISOHATA, T. HIGUCHI and M. SHIMADA : *Biosci. Biotech. Biochem.*, **58**, 230 (1994).

The *Forsythia koreana* plant produces such lignans as (−)-secoisolariciresinol, and (+)-pinoresinol. Cell-free extracts from the plant catalyzed the enantioselective formation of (−)-[$^2H_{10}$] secoisolariciresinol from [9, 9-$^2H_2$, OC$^2H_3$] coniferyl alcohol in the presence of NADPH and H_2O_2. On the other hand, [$^2H_{10}$] lariciresinol isolated from the enzymatic reaction products was found to be predominantly composed of the unnatural (−)-enantiomer [88% enantiomer excess (*e.e.*)]. The stereoselectivity for the formation of these lignans can be explained, at least in part, by the finding that the enzyme system also catalyzed the stereoselective reduction of (+)-lariciresinol, but not its (−)-enantiomer, to (−)-secoisolariciresinol.

Syntheses of (±)-lariciresinols, T. UMEZAWA and M. SHIMADA : *Mokuzai Gakkaishi*, **40**, 231 (1994).

We report a new method for the total syntheses of (±)-lariciresinols, using (±)-β-(4-benzyloxy-3-methoxybenzyl)-γ-butyrolactones. Our method can be applied to the syntheses of optically pure (+)- and (−)-lariciresinols, because the preparation of optically pure (+)- and (−)-enantiomers of the γ-butyrolactone were established previously.

Lignans, T. UMEZAWA : "Wood Molecular Biology", T. Higuchi ed., Bun'eido, pp. 140–145 (1994) (in Japanese).

Recent advances in lignan biosynthesis research were reviewed.

Molecular architecture of the cell wall of poplar cells in suspension culture, as revealed by rapid-freezing and deep-etching techniques, T. ITOH and T. OGAWA : *Plant Cell Physiol.*, **34**, 1187–1196 (1993).

The architecture of the primary cell wall of poplar cells in suspension culture was observed after application of rapid-freezing and deep-etching techniques both before and after the sequential extraction of cell wall polysaccharides. The architecture of the cell wall was also examined after treatment with pectin-degrading enzymes. The dimensions of interfibrillar spaces or pores increased after the extraction of pectins by chemical or enzymatic treatment. The ordered spacing of cellulose microfibrils was only slightly altered after treatment with 0.7 M KOH but was dramatically altered after treatment with 4.3 M KOH. These results suggest that a hemicellulose, perhaps xyloglucan, may have a substantial role in maintaining the three-dimensional conformation via interfibrillar polysaccharide lindages in the cell wall of this dicotyledonous species.

The occurrence of calcium oxalate crystals in the cell walls of the secondary phloem of Taxodiaceae, T. ITOH and K.D. KANG: *Holzforsch.*, **47**, 465–472 (1993).

Crystals were found in the intercellular layer or middle lamella of the radial walls of the secondary phloem in all species examined in Taxodiaceae. Deposition of the crystals is initiated in the cell walls of immature phloem cells adjacent to the cambium and they are distributed throughout the living secondary phloem. The crystals are absent from rhytidome except in *Glyptostrobus, Metasequoia* and *Taxodium* in which crystals were often found in the innermost tissue layer of rhytidome. The seasonalchanges in the distribution of the crystals in the cell walls of *Cryptomeria japonica* indicate that the crystals disappear from the oldest annual ring of the living secondary phloem which is destined to change into rhytidome in June. These phenomena suggest the involvement of phellogen activity in the disappearance of the cystals from the cell walls of Taxodiaceae. The amount of such crystals varies from species to species; the largest amounts of crystals were observed in *Taxodium distichum.* Energy-dispersive X-ray analysis and acid treatment demonstrated that the crystals are composed of calcium oxalate.

Molecular organization of plant cell wall, three dimensional visalization by rapid freezing and deep etching techniques, T. ITOH: *Kagaku to Seibutu,* **31**, 724–725 (1993) (in Japanese).

Recent advances of rapid freezing and deep etching techniques to visualize molecular organization of plant cell walls was reviewed.

Tree species of Wooden articles excavated from Ishikawa Jyouri Relics, T. ITOH, T. MITUTANI and T. NUNOTANI: *Nagano Center for Buried Cultural Properties 9,* Nagano Center for Buried Cultural Properties, 73–78 (1992).

Native celluloses on the bases of two phase (I_α/I_β) system, M. WADA, J. SUGIYAMA and T. OKANO: *J. Appl. Polym. Sci.*, **49**, 1491–1496 (1993).

A survey by X-ray diffractometry was carried out to confirm the two crystalline phase (I_α/I_β) system of native cellulose. 12 samples from different origins were investigated and the d-spacings were evaluated with reasonable precision. From the statistical analysis using sets of d-spacing data, all the cellulose samples were categorized into the two groups that coincide with the two crystalline phases: one is the algal-bacterial type rich in triclinic phase and the other is the cotton-ramie type of the monoclinic phase.

Morphology and structure of crystalline cellulose, J. SUGIYAMA, N. HAYASHI, M. WADA and T. OKANO: "Trichoderma reesei celluloses and other hydrolases", Pirkko Suominen and Tapani Reinikainen, Foundation for Biotechnical Industrial Fermentation Research, **8**, 15–23 (1993).

Resent advances on the knowledge of cellulose microfibrils were reviewed with a

particular references to the two crystalline phase system.

Visualization of the adsorption of a bacterial endo-β-1, 4-glucanase and its isolated cellulose-binding domain to crystalline cellulose, N.R. GILKES, D.G. KILBURN, R.C. MILLER, JR., R.A.J. WARREN, J. SUGIYAMA, H. CHANZY and B. HENRISSAT : *Int. J. Biol. Macromol.,* **15**, 347–351 (1993).

Adsorption of endo-β-1, 4-glucanase A and its cellulose binding domain to *Valonia* cellulose microcrystals was examined by TEM using an antibody sandwich technique. In both cases, adsoption occured along the length of the microcrystals, with an apparent preference for cetain crystal face or edges. The adsorption results in prevention of flocculation of microcrystalline celluloses. The cellulose-binding domain may thus assist crystalline cellulose hydrolysis in vitro by promoting substrate dispersion.

The monoclinic phase is dominated in wood cellulose, M. WADA, J. SUGIYAMA and T. OKANO : *Mokuzai Gakkaishi,* **40**, 50–56 (1994).

To evaluate whether wood celluloses belong to algal-bacterial type celluloses or cotton-ramie type celluloses, a discriminant analysis was conducted by using d-spacing data from X-ray diffractometry. The discrimintant function was successfully introduced and thus concluded that the wood celluloses belong to cotton-ramie type celluloses, being rich in monoclinic crystals.

On the cell wall polarity in *Valonia* cellulose, J. SUGIYAMA, H. CHANZY and J.F. REVOL : *Planta.* **193**, 260–265 (1994).

The orientation of the triclinic phase of cellulose in the cell wall of *Valonia* was investigated by X-ray and electron diffraction analysis. In addition to the well documented uniplaner-axial organization of the cell wall which requires that the a* axis should be always perpendicular to the wall surface, the direction of this axis was also found to be pointing outward from the plasmamembrane side of wall. This unidirectionality of the a* axis was persistent throughout the various layers that constitute the cell wall and also for the three microfibrillar orientations that occur in *Valonia* cell walls.

Delignification and production of ligninolytic enzymes by eddible mushromms, M. KUWAHARA, H. KOFUJITA, Y. ASADA, T. WATANABE and J.-Y. ZHOU : *Seventh International Symposium on Wood and Pulping Chemistry,* Beijin, Proceedings Vol. **2**, 709–713 (1993).

During the course of delignification of wood meal, white-rot fungi *Phanerochaete chrysosporium, Lentinus edodes* and *Pleurotus ostreatus* produced Mn(II)-peroxidase. However, lignin peroxidase activity was not detected in this culture condition. In the liquid cultures of *L. edodes* and *P. ostreatus,* lignin peroxidase activity was not found. In a glucose-peptone medium, *P. ostreatus* produced Mn(II)-peroxidase as a mixture of at least two isozymes and these protein were purified and characterized. Laccase activity was found both in the

liquid and wood-meal cultures of *L. edodes* and *P. ostreatus*. Laccase produced in the wheat-bran culture by *L. edodes* was purified and characterized. Mn(II)-peroxidase and laccase activities were also detected in the liquid cultures of *Coriolus* species and other strains of Basidiomycetes.

Lignin degrading basidiomycetes—Production of ligninolytic enzymes and utilization in pretreatment of lignocellulose, M. KUWAHARA: Mie Bioforum 93, Genetics, Biochemistry and Ecology of Lignocellulose Degradation, Toba, Abstract pp. 128–129 (1993).

White rot fungi, *Lentinus edodes* and *Pleurotus ostreatus,* produced manganese peroxidase in wood-meal cultures, whereas activity of lignin peroxidase, which was the dominant ligninolytic enzyme of *P. chrysosporium,* was undetectable both in the liquid and wood-meal cultures. Southern hybridization using the fragments of lignin peroxidase DNA as probes showed *Bjerkandera adusta* had the gene to be expressed in the liquid culture.

Steam-explosion was effective for pretreatment of wood materials for hydrolysis by cellulose. Fugal treatment using *P. chrysosporium* preier to explosion was shown to give additional enhancement to improve suseptibility to enzymatic saccharification of the treated wood materials.

Reaction of polyethylene glycol-modified lignin peroxidase in organic solvent, S. YOSHIDA, T. WATANABE and M. KUWAHARA: Mie Bioforum 93, Genetics, Biochemistry and Ecology of Lignocellulose Degradation, Toba, Abstract pp. 88–89 (1993).

Lignin peroxidase (LiP) from *Phanerochaete chrysosporium* was chemically modified with methoxypolyethylene glycol-succinimidyl succinate (MPSS) and 2, 4-bis(*O*-methoxypoly-ethylene glycol)-6-chloro-*s*-triazine (activated PEG_2). LiP modified with activated PEG_2 (LiP-PEG_2) was denatured during the modification, while LiP modefied with MPSS (LiP-MPSS) retained its original activity in aqueous solution. GC-MS analysis of the reaction products in organic solvents revealed that 3, 4, 5-trimethoxybenzyl alcohol (TMBA) was oxidized by the LiP-MPSS in benzene, while the native LiP was inactive to TMBA in organic solvents. Furthermore, reactivity of LiP-MPSS to veratryl alcohol was higher than that of TMBA in aqueous solutions, while the reverse substrate specificity was observed in the reactions of LiP-MPSS in benzene. Intial rate of the oxidation by LiP-MPSS in benzene was about 1/300 of that observed in aqueous solution.

Microorganism system participating in biodegradation of wood—Enzyme chemistry and molecular microbiology of lignin degradation, M. KUWAHARA: *Chemistry and Biology,* **32**, 171–180 (1993) (in Japanese).

Biodegradation of lignin is important on both of the view points of utilization of resources and carbon cycle in the natural enviroment on the earth. Althought the

mechanism of lignin biodegradation has long been unclarified, the experimental data accumulated so far showed that some sorts of peroxidase degrade lignin. Recent studies on the structure of genes encoding these enzymes may clarified the differences between lignin-degrading peroxidases and lignin-nondegrading peroxidases.

Determination of ester bonds between lignin and glucuronoxylan in *Fagus crenata* Wood, T. WATANABE, T. IMAMURA, T. KOSHIJIMA and M. KUWAHARA : *Proceedings of 7th International Symp. on Wood and Pulping Chem.*, **1**, 82–86 (1993).

Acid conjugated oxidation of benzyl esters with 2, 3-dichloro-5, 6-dicyano-1, 4-benzoquinone (DDQ) and trifluoroacetic acid (TFA) was applied to the binding site analysis of ester linkages between lignin and glucuronoxylan in *Fagus crenata* wood. Based on the acid-conjugated DDQ-oxidation of a water-soluble lignin-carbohydrate complex (LCC-WE) from the beech wood, frequency of the ester bonds between the lignin and glucuronic acid residue of the glucuronoxylan was determined to be 1.6 per molecule of LCC-WE.

Functional difference between the two oppositely oriented priming signals essential for the initiation of the broad host-range plasmid RSF1010 DNA replication, K. TANAKA, K. KINO, Y. TAGUCHI, D. MIAO, Y. HONDA, H. SAKAI, T. KOMANO and M. BAGDASARIAN : *Nucl. Acids Res.*, **22**, 767–772 (1994).

The broad host-range plasmid RSF1010 contains two oppositely oriented priming signals, *ssiA* and *ssiB*, for DNA synthesis dependent on *oriV*. If either *ssiA* or *ssiB* was deleted or inverted, the recombinant mini-RSF1010 plasmids were maintained at low copy numbers, replicated as in dimers and accumulated specific single strands in *Escherichia coli* host cells. Interestingly, Sog primase supplied by plasmid ColIb-P9 reversed completely the dificiency of these miniplasmids DNA replication. These results were also the case for the recombinant miniplasmids in which either *ssiA* or *ssiB* was replaced by the primosome assembly site (PAS) or the G4-type *ssi* signals (G sites). Futhemore, comparative analysis of the functional contribution of the signals showed that, irrespective of their types, *ssi* signals conducting the initiation of DNA chain elongation away from the iterons were functionally more important than ones in the inverted orientation. This functional difference seems to reflect the inherent properties of the initiation mechanism of RSF1010 DNA replication.

Functional features of *oriV* of the broad host range plasmid RSF1010 in *Pseudomonas aeruginosa*, A. HIGASHI, H. SAKAI, Y. HONDA, K. TANAKA, D. MIAO, T. NAKAMURA, Y. TAGUCHI, T. KOMANO and M. BAGDASARIAN : *Plasmid*, **31**, 196–200 (1994).

Replicative properties of recombinant origin sequences of the broad host range plasmid RSF1010 in *Pseudomonas aeruginosa* were analized. DNA replication of recombinant mini-RSF1010 plasmids were dependent on the three plasmid-encoded proteins RepA, RepB′ and

RepC as in *Escherichia coli*. Miniplasmids lacking *ssiB* replicated in neither of *P. aeruginosa* and *E. coli*. However, miniplasmids lacking *ssiA* replicated only in *P. aeruginosa*. Futhermore, *ssiA* in the orientation that *ssiB* has originally taken was sufficient for the miniplasmid DNA replication. It was also shown that primosome assembly site did not substitute for the *ssi* signals in *P. aeruginosa*. These results indicate that, in *P. aeruginosa*, only one *ssi* signal in the orientation of original *ssiB* is sufficient for the plasmid DNA replication and initiation requirments are not so much stringent as in *E. coli*.

Fixation of compressive deformation by hygro-thermal treatment using moisture in wood, M. INOUE, N. KADOKAWA, J. NISHIO and M. NORIMONO : *Wood Research and Technical Notes,* No. **29**, 54–61 (1993) (in Japanese).

We developed a new process to permanently fix the compressive deformation of wood, in which the hygro-thermal treatment using moisture in wood in a closed system was applied. Sugi (*Criptomeria japonica* D. Don) specimens were compressed in radial direction and heated in the hot press equipped with airtight seal of a silicone sheet. After the treatment, the specimens were rapidly quenched in the press.

The recovery of the compression set after boiling in water decreased with increasing of heating time and temperature. The fixation of the set was achieved when the specimens of 17% moisture content were compressed over 8 minutes at 180°C. However, the effect of the treatment on the fixation could not be observed for the dry specimen, so that it is clear that the moisture in wood acted on the fixation of the deformation.

Steam or heat fixation of compressed wood, M. INOUE, M. NORIMOTO, M. TANAHASHI and R.M. ROWELL : *Wood and Fiber Science,* **25**(3), 224–235 (1993).

Dimensional stability can be improved by either steaming or heating wood while the wood is in a compressed state. This study investigated the effect of steam or heat on fixation of compression set and the effect of these treatments on hardness, mechanical properties, and color of compressed and uncompressed wood specimens. To determine the effect of steaming before and after compression set, one group of wood specimens was steamed and then compressed, and another group was compressed and then steamed. Simple boiling and cyclic swelling tests were used to evaluate recovery of compression set. Hardness of compressed specimens was measured by the Brinell test. A two-point bending test on noncompressed specimens was used to calculate moduli of elasticity and rupture. A L-a-b color system was used to determine color changes. Compressed wood steamed for 1 min at 200°C or 8 min at 180°C showed no recovery of set, large increases in hardness, minimum decreases in mechanical properties, and slight darkening. We conclude that almost complete fixation of compression set in wood can be achieved by steaming compressed wood.

Fixation of compressed wood using melamine-formaldehyde resin, M. INOUE, S. OGATA, S. KAWAI, R.M. ROWELL and M. NORIMOTO : *Wood and Fiber Science,* **25**(4), 404–410 (1993).

Methods to maximize wood hardness and dimensional stability include various combinations of compression, heating, and chemical treatment. In this study, wood was treated with increasing concentrations of a low molecular weight, water-soluble melamine-formaldehyde resin solution (mol wt 380) and compressed while heated. This method achieved a maximum bulking efficiency of 5% and an antishrink efficiency of 45%, showing that the chemical had not completely penetrated the cell wall. Once the wood was treated, its ability to retain the compressed state was tested by immersing wood specimens in water at different temperatures. Specimens treated with an 8% resin solution retained almost complete fixation when soaked in room-temperature water, while those treated with a 25% solution retained fixation in boiling water. Moreover, a 25% solution of resin and a compression of 54% increased hardness from 0.48 to 0.72 MPa.

The large compressive deformation of wood in the transverse direction I., Relationships between stress-strain diagrams and specific gravities of wood, Y. LIU, M. NORIMOTO and T. MOROOKA : *Mokuzai Gakkaishi,* **39**(10), 1140–1145 (1993).

The compressive tests in the radial direction for 17 hardwoods were conducted under three conditions ; namely, the air-dried condition at 20°C, the wet condition at 20°C and the wet condition at 100°C. Although the stress (σ)-strain (ε) diagrams obtained were different under the different conditions, they could be expressed by the following with the two parameters of C and K.

$$\varepsilon \leqq \varepsilon_y \quad \sigma = E\varepsilon$$

$$\varepsilon > \varepsilon_y \quad \sigma/\sigma_y = 1 + C\{\varepsilon_d/[\varepsilon_d - (\varepsilon - \sigma_y/E)] - 1\}$$

$$\varepsilon_d = 1 - K(\rho/\rho_s)$$

where σ_y, ε_y, E, ρ, and ρ_s refer to yield stress, yield strain, Young's modulus, specific gravity of the wood, and specific gravity of the cell walls, respectively. The value ε_d is a measure of the strain when all of the pore space in wood is squeezed out. Parameter C indicates the extent of the increase of stress with strain above the yield point. Parameter K is related to Poisson's ratio in large deformations. Parameter C was little affected by the viscoelastic properties of the cell walls, whereas Parameter K decreased with increasing specific gravity of the wood.

Structure and properties of chemically treated woods, M. NORIMOTO and J. GRIL : "Recent Research on Wood and Wood-Based Materials, Current Japanese Material Research Vol. **11**" N. Shiraish, H. Kajita and M. Norimoto, eds., p. 135–154 Elsevier Applied Science, London and New York, 1993.

Chemically treated woods are classified by using a model of the structural change in the cell wall and the lumen of a cell resulting from the treatment. The dimensional stabilization of wood by chemical treatment is discussed, based on a generalized concept of the dimensional stability that allows for the deformation due to the simultaneous action of moisture changes and external forces applied to the material. Typical cases of chemical treatment are used to outline the relationship between the structural changes involved and the resulting properties.

Stabilization of acoustical properties of wooden musical instruments by acetylation, H. YANO, M. NORIMOTO and R.M. ROWELL : *Wood and Fiber Sci.,* **25**(4), 395–403 (1993).

Because variable humidity affects the acoustic properties of wood, manufacturers of wood instruments must minimize dimensional changes caused by the absorption of water. Acetylation reduces the moisture content of the cell wall, thereby increasing the stability of the acoustic and dimensional properties of wood under conditions of changing humidity. The acetylation of wood slightly reduces sound velocity (by about 5%) and also reduces sound absorption when compared to unreacted wood. Hence, acetylation does not change the acoustic converting efficiency.

Relationships between dielectric properties and dimensional stabilities of formaldehyde-treated wood, N. KAMEYAMA, H. YANO, K. MINATO and M. NORIMOTO : *Mokuzai Gakkaishi,* **40**(4), 399–406 (1994).

Cross section specimens of sitka spruce (*Picea sitchensis* Carr.) were treated for 22 hours at 120°C in the presence of tetraoxane, a reagent source of formalization, and sulfur dioxide catalyst. The reaction levels were controlled by varying the amounts of tetraoxane added to the reaction system. The dielectric properties in the longitudinal direction and dimensional stabilities in cross-sections were determined and compared with uncatalyzed acetylation.

The oven-dry dielectric dispersion magnitude at −80°C due to the orientation of methylol groups decreased to 60% of the control accompanied with increasing weight gains. The degree of the reduction was a half of that obtained by acetylation. The distribution of relaxation time spread out with increasing weight gains. Also, the apparent activation energy corresponding to the rotation of methylol groups increased with weight gain, and was about 1.5 kcal/mole more than that of the control at the maximum. Dimensional stability of the formaldehyde-treated wood decreased less than about 0.7. The relationship between dielectric dispersion magnitude and the antiswelling efficiency showed that greater dimensional stability was attained by the formalization than by the acetylation at a definite degree of substitution of methylol groups.

Chemical modification of wood by non-formaldehyde cross-linking reagents, Part 2. Moisture adsorption and creep properties, R. YASUDA, K. MINATO and M. NORIMOTO: *Wood Science and Technology,* **28**(3), 209–218 (1994).

The features of the reaction between sitka spruce wood and non-formaldehyde reagents, i.e. glyoxal, glutaraldehyde, and dimethylol dihydroxy ethyleneurea (DMDHEU), were investigated from the aspects of moisture adsorption and bending creep properties. To the moisture adsorption data, Hailwood-Horrobin adsorption equation was applied, and whole adsorbed water was separated into hydrated water and dissolved water which correspond to monolayer and multilayer adsorption, respectively. In the treatments with non-formaldehyde reagents, the decrease of equilibrium moisture content was mainly attributed to the decrease of dissolved water, but not largely to that of hydrated water. This suggested that the reagent in the multilayer adsorption region contributed pronouncedly to suppress the moisture adsorption by the bulking and cross-linking effects, but that the reagent in the monolayer adsorption region did not considerably. The creep deformation and remaining strain of the specimens treated with glyoxal and glutaraldehyde were as small as those of formaldehyde treatment. Also by the DMDHEU treatment, creep deformation was restrained to some extent. The eminent creep restraint effect by these treatments showed the formation of cross-linkings, although the cross-linkings were not stable to the drastic water leaching.

Large compressive deformation in wood, M. NORIMOTO: *Mokuzai Gakkaishi,* **39**(8), 867–874 (1993).

Recent investigation on the large compressive deformation of wood in the transverse direction and the methods of its permanent fixation was reviewed.

Wood and living environments, Wood as a model to develop new materials, M. NORIMOTO: *Chemistry and Chemical Industry,* **47**(6), 747–749 (1994).

Properties of wood as a finish material in living environment were summarized.

Growth of Moso bamboo (*Phyllostachys heterocycla* (carr.) Mitford) stractural and dimensional change of bamboo tissue along with the aging of seedling bamboo, T. NOMURA: *Bamboo Journal,* No. **11**, 54–62 (1993).

The shape of the vascular bundle including the bundle sheath of Moso bamboo (*Phyllostachys heterocycla* (carr.) Mitford) is classified into three different types according to the radial direction of the culm : A type, the shape of the outermost vascular bundle looks as if it were being compressed tangentially ; B type, that of the middle part is circular ; C type, that of the inner side looks as if it were being stretched tangentially to the direction of the culm.

This report deals with the dimensional and structural changes of the vascular-bundle in relation to the changes in diameter of the bamboo culm in seedling Moso bamboo using a

scanning electron microscope. The results were as follows.

It was observed that only type B exists in 1 to 2 year old culm while both B and C types exist in three year old seedling bamboo. In 5 year old bamboo, all three types of vascular bundle were recognized.

The dimensional changes in the vascular bundle including bundle sheath and reticulate vessel also increased linearly as seedling bamboo grew older.

The average diameter of the former in mature bamboo was 6.7 times that of 1 year old bamboo and 4.4 times that of the latter. Fiber length also increased linealy along with the aging and was about 1.9 times that of the 1 year old in mature bamboo. The tissue neighbouring the pith cavity also changed during the growth stage along with the aging of seedling bamboo. In mature bamboo, the structure of this cell tissue was different from that of parenchyma cell, and its average size was $26(L) \times 30(R) \times 61(T)\ \mu$, or 0.21 times the average volume of parenchyma cell. It could not be detected in 1 and 2 year old bamboo and only appeared after three years growth. The appearance of this cell tissue coincided with the appearance of both B and C types of vascular bundle.

Biology of brown-rot fungi, M. TAKAHASHI: *Mokuzai Hozon* (*Wood Preservation*), **19**, 143–153 (1993) (in Japanese).

Brown-rot fungi are minor group in wood-decay fungi but are very important in the field of wood preservation because they have a preference to softwood that have been utilized as structural member in wooden buildings. Review was made on taxonomy, distribution, ecology, mechanism of wood decay, and evolution, comparing with those of white-rot fungi.

Wood-preserving techniques to prevent biodeterioration, M. TAKAHASHI: "Recent Research on Wood and Wood-Based Materials, Current Japanese Material Research Vol. **11**", p. 223–240, N. Shiraishi, H. Kajita and M. Norimoto eds., p. 223–240, Elsevier Applied Science, London and New York, 1993.

Current wood-preserving techniques for preventing biodeterioration are reviewed. Contents are as follows: Development of alternatives to conventional wood preservatives (oil-borne preservatives, water-borne preservatives), Improvement of preservation treatment (pressure treatment, superficial treatment), Enhancement of biological resistance by chemical treatment (chemical modification, phenolic resin impregnation, wood-inorganic material composites), and Future consideration.

***(Z, E, E)*-dodecatrien-1-ol: A minor component of trail pheromone of termite, *Coptotermes formosanus* Shiraki,** M. TOKORO, M. TAKAHASHI and R. YAMAOKA: *J. Chemical Ecology*, **20**, 199–215 (1994).

In the course of the elucidation of the primary structure of an isolated trail pheromone from *C. formosanus*, a minor component that had the same molecular weight as the major trail

pheromone, (*Z, Z, E*)-3, 6, 8-dodecatrien-1-ol [(*Z, Z, E*)-DTE-OH], was detected in the mass chromatogram of *m/z* 180 of capillary GC-MS. The mass spectrum of the minor component showed a prominent pattern of dodecatrien-1-ol. Chemical analysis demonstrated that the complete structure was (*Z, E, E*)-DTE-OH. Furthermore, capillary GC-MS-HR-SIM analysis indicated that the component existed only in the workers of *Coptotermes formosanus* Shiraki and was not present in workers of *Reticulitermes speratus* (Kolbe). This minor component may be a species-specific factor of *C. formosanus,* although this was not suggested by a two-choice bioassay.

Hygroscopic, vibrational, and biodeterioration characteristics of medium density fiberboard treated with formaldehyde, K. MINATO, S. YUSUF, Y. IMAMURA and M. TAKAHASHI: *Mokuzai Gakkaishi,* **39**, 190–197 (1993).

The effects of a formaldehyde treatment (formalization) on medium-density fiberboard (MDF) were comprehensively evaluated from the viewpoints of dimensional stability, hygroscopicity, vibrational property, and resistance to biodeterioration. The thickness swelling and equilibrium moisture content of the MDF treated with formaldehyde decreased in the entire relative humidity range. Even when heated without formaldehyde, they decreased in low humidity range, but rather increased high humidity range, which suggested that the spring back of the remaining strain due to the thermal degradation of adhesive resin and the resultant appearance of moisture adsorption sites. The antiswelling efficiency and moisture excluding efficiency of the treated MDF varied depending on the relative humidity when they were evaluated ; the less the relative humidity, the greater the values were. With the moderate degree of the treatment, which does not cause serious degradation of bonding, the specific dynamic Young's modulus increased, and the loss tangent decreased. The formaldehyde-treated MDF significantly resisted attack by *Coriolus versicolor* (L. ex. Fr.) Quel. and with exposure in unsterile soil, to *Tyromyces palustris* (Berd. et. Curt.) Murr., the adhesive resin involved in the MDF hindered its attack. Supplemental effects by the formalization were not detected. In the forced feeding tests with termites, significant insecticidal effect was observed ; however, the weight loss was not always small. This suggests that the treatment does not result in the evasion of ingestion but instead some digestive trouble.

Biological resistance of phenolic resin-treated compressed laminated veneer lumber, K. TSUNODA and S. KAWAI: "Protection of wood-based composite products", A.F. Preston ed., Forest Prod. Research Society, USA, p. 18–22 (1993).

Rotary veneers of *Cryptomeria japonica* D. Don (Japanese cedar, 3 mm in thickness) were dip-treated with an aqueous solution of low molecular weight phenolic resin. Six-ply laminated veneer lumbers (LVLs) were assembled from the treated (approximately 40 and 13% weight gain for sapwood and heartwood veneers, respectively) and untreated veneers,

and compressed into target thickness of 6–18 mm prior to laboratory and field biological testing. Phenolic resin-treated sapwood LVLs performed well in the laboratory decay test against the monoculture of two decay fungi, *Coriolus versicolor* (L. ex Fr.) Quelet and *Tyromyces palustris* (Ber. et Curt.) Murr., whereas compressed LVLs proved decay-resistant to some extent without impregnation of phenolic resin. Termite resistance was greatly improved by phenolic resin when the treated sap-wood LVLs were exposed to Formosan subterranean termite *Coptotermes formosanus* Shiraki in the laboratory, and tended to increase with the degree of compression. High biological resistance of untreated heartwood samples did not allow comparison of effectiveness among phenolic resin treatments and degree of compression. Feild evaluations suggested that phenolic resin-treated compressed LVLs were not immune from attacks of subterranean termites on the basis of the performance requirements prescribed in JWPA Standard 14 (1981).

Wood preservative effectivenss of metallic naphthenates (1) Laboratory evaluation of the chemicals as fungicidal and termiticidal agents, K. TSUNODA and M. SAKURAI: *Mokuzai Hozon (Wood Preservation),* **19**(6), 272–280 (1993) (in Japanese with English summary).

A series of metallic naphthenates were tested for their fungicidal and termiticidal effectiveness in the laboratory. Copper naphthenate peformed better than zinc naphthenate in wood decay control.

In vacuum/soak impregnation treatment [JIS A 9301 (1976)], copper and zinc naphthenates could satisfactorily depress decay fungi at retentions of 0.5 and 1.0 kg/m^3 as an elemental metal, respectively [JIS A 9302 (1976)]. The former chemical proved effective in protecting timber from decay at 2.1 kg/m^3 even after the recently amended severer leaching schedules [JIS A 9201 (1991)]. When applied to brush treatment, copper naphthenate was effective at 2% Cu and 3% Cu concentrations, respectively after weathering of JWPA Standard 1 (1979) and the severer weathering [amended JWPA Standard 1 (1989)], while zinc naphthenate did not perform well even at 4% Zn after the new weathering scheme. Noticeable effects of acid values were not shown for copper naphthenates, but for zinc naphthenates in brush application.

As for the termiticidal effects of the test chemicals, copper naphthenate was efficacious at 1% Cu in wood block test [JWPA Standard 11 (1) (1981)] in which pine sapwood blocks treated with the chemicals by brushing were exposed to Formosan subterranean termites for three weeks. Zinc compounds were less effective, and 2% Zn was required to control termite attacks.

Methane emission by the termite, *Coptotermes formosanus* Shiraki (Isoptera: Rhinotermitidae) (II) Presence of methanogenic bacteria and effect of food on methane emission rates, K. TSUNODA, W. OHMURA and T. YOSHIMURA: *J. Environ. Entomol.*

Zool., **5**(4), 166–174 (1993).

Epifluorescence microscopic observations showed that methanogenic bacteria was associated with the smallest-sized protozoa *Spirotrichonympha leidyi* Koidzumi, while any presence of the associated methanogens was not confirmed in the other two symbiotic protozoan species (*Pseudotrichonympha grassii* Koidzumi and *Holomastigotoides hartmanni* Koidzumi). The findings suggested that each symbiotic protozoa had its own specialized role in the hindgut ecosystem of *Coptotermes formosanus* Shiraki. A weekly measurement demonstrated that worker termites did not produce more than 0.3 nmol/termite/hr during a 6-hour period in any case after transferring the test animals from an incubation chamber to a 100 ml Erlenmeyer flask as a gas sampling unit, when the termites were fed on pine wood blocks and Avicel at 28±2°C for 12 weeks in the laboratory. Methane emission rates gradually went down with time for the first 5 weeks, and then recovered up to 57–87% of the initial level. Termites fed on CMC, low-molecular weight cellulose and starch tended to decrease methane formation until no methane was detected 8–10 weeks after incubation. A long-term artificial incubation being separate from a mother colony seemed to result in the less production of methane by termites based on the present investigations. Although physiological disturbance of termites induced by experimental operations might account for the phenomenon, further examinations will be needed for the better understanding. Addition of soil materials into an incubation container did not have any effect on mathane production by termites when fed with pine wood blocks in the laboratory. Comparative studies should be planned to fully elucidate the effect of experimental conditions on termite methane production.

Effect of gaseous treatment with allyl isothiocyanate on the control of microbial growth on a wood substrate, K. Tsunoda : *J. Antibact. Antifung. Agents,* **22**(3), 145–148 (1994).

Gaseous (fumigant) treatment with allyl isothiocyanate (AIT) was tested for its effect in controlling the microbial growth on a wood substrate. When an AIT-treated filter paper was placed with fungus-inoculated wood specimens in a sealed Petri dish, the effect of AIT on the fungal growth depression varied with the test fungi. Toxic limits of AIT for the five test fungi were : >118 ppm AIT in the air for *Rhizopus javanicus* 59–118 ppm for *Penicillium funiculosum,* 30–59 ppm for *Gliocladium virens,* 7.5–15 ppm for *Aspergillus niger,* and <3.8 ppm for *Aureobasidium pullulans.*

Nutritional symbiosis in wood-attacking insects, T. Yoshimura : *Wood Research and Technical Notes,* **29**, 39–53 (1993) (in Japanese).

Wood-attacking insects have developed diverse nutritional symbiosis with micro-organisms in order to utilize wood as their diets. The review focuses on the characteristics of these unique symbiotic systems, especially termite-symbionts relationships.

Cellulose metabolism of the symbiotic protozoa in termite, *Coptotermes formosanus* Shiraki (Isoptera : Rhinotermitidae) III. Utilization of non-natural celluloses, T. YOSHIMURA, J. AZUMA, K. TSUNODA and M. TAKAHASHI : *Mokuzai Gakkaishi,* **39**, 1322–1326 (1993).

The changes of survival rates, weights of workers, and numbers of differentiated soldiers suggested that two non-natural celluloses, cellulose II and amorphous cellulose, as well as cellulose I were utilized by workers of *Coptotermes formosanus* Shiraki when the termite workers were forced to feed on these substrates. In addition, the existence of three symbiotic protozoa indicated that all protozoan species were involved in the metabolism of these non-natural celluloses.

A novel defaunation method of the protozoa to investigate cellulose metabolism in *Coptotermes formosanus* Shiraki (Isoptera : Rhinotermitidae), T. YOSHIMURA, K. TSUNODA and M. TAKAHASHI : *The Int. Res. Group on Wood Preserv.*, Document No. IRG/WP 94-10050, pp. 5 (1994).

The largest protozoa in the hindgut of workers of Formosan subterranean termite, *Coptotermes formosanus* Shiraki, was selectively eliminated by forced-feeding on low molecular-weight cellulose (LC) with a mean DP of 17. Although one week's feeding on LC caused perfect disappearance of *Pseudotrichonympha grassii* Koidzumi, the selective defaunation method itself had no detrimental effect of the health conditions of termite on the basis of survival rates and weight changes of workers in the latter feeding. In addition, the fact that the defaunated workers repidly recovered their wood-attacking activity by being mixed with normally faunated workers could well support this assumption. By the results of changes of protozoan fauna when selectively defaunated workers were forced to feed on various cellulose substrates, it was suggested that each protozoan species had its inherent role in cellulose metabolism.

Laboratory evaluation of six commercial termiticides against subterranean termite, *Coptotermes gestroi* Wasmann, Y. SORNNUWAT, C. VONGKALUANG, T. YOSHIMURA, K. TSUNODA and M. TAKAHASHI : *The Int. Res. Group on Wood Preserv.*, Document No. IRG/WP 94-30034, pp. 7 (1994).

Small specimens of *Heavea brasiliensis* Muell.-Arg. (10×10×20 mm) were exposed to the laboratory colony of *Coptotermes gestroi* Wasmann for 4 months after dip- or brush-treatment with six commercially available emulsifiable termiticides (alpha-cypermethrin, cypermethrin, permethrin, bifenthrin, chlorpyrifos and chlordane). Synthetic pyrethroids and chlorpyrifos were effective as well as 1% treatment of chlordane at lower concentrations. No marked difference in effectiveness was noticed between dip- and brush-treatments. Field trials will be planned to examine their efficacy in the actual conditions in the search for alternative termiticides.

Formaldehyde-treated wood, K. MINATO and S. YUSUF: *Mokuzai Hozon (Wood Preservation),* **20**(1), 2–9 (1994) (in Japanese).

Vaporous formaldehyde treatment was applied to solid wood and wood products and their effects on physical properties, acoustic properties and biological resistance were discussed.

Biological resistance of aldehyde-treated wood, S. YUSUF, Y. IMAMURA, M. TAKAHASHI and K. MINATO: *The Int. Res. Group on Wood Preserv.,* Document No. IRG/WP/94-40035, pp. 14 (1994).

Biological resistance of wood treated with aldehyde cross-linking agents such as glyoxal, glutaraldehyde and dimethylol dihydroxy ethyleneurea (DMDHEU) were investigated. Sapwood blocks of Japanese cedar and Japanese beech, measuring 20 mm (T) × 20 mm (R) × 10 mm (L), were vacuum-impregnated at room temperature with 5–25% of aldehyde solutions. Blocks were kept in the solution for 1 week, and cured at 120°C for 24 h, under SO_2-catalysis. After treatment, they were thoroughly rinsed in running water for several days to leach out the unreacted aldehyde agent. Biological resistance tests were conducted in laboratory by exposing to brown-rot fungus *Tyromyces palustris,* white-rot fungus *Coriolus versicolor,* and the two subterranean termites, *Coptotermes formosanus* and *Reticulitermes speratus.*

Glutaraldehyde was most effective to eliminate the attack of Japanese cedar by all test organisms. Decay by both fungi was almost nil in the treated cedar even at the lowest 5% solution of this agent. A complete death of both termites was gained also in glutaraldehyde-treated cedar at the same concentration. DMDHEU treatment was also effective to enhance the biological resistance of Japanese cedar. Enhancement of biological resistance was recognized also in Japanese beech treated with these agents, but it was somewhat lower than in Japanese cedar. Such difference might be related to the value of dimensional stability resulted from the treatments. Glyoxal treatment exhibited thoroughly a poor effect to improve the biological resistance and the dimensional stability of both wood species.

Fire-resistant carbon based-board materials. III. Thermal decomposition of constituents of particleboards overlaid with graphite-phenolic spheres, I. IDE, S. ISHIHARA, H. HIGUCHI and M. NISHIKAWA: *Mokuzai Gakkaishi,* **39**(12), 1449–1457 (1993) (in Japanese).

To clarify the necessity of fire-resistant carbon-overlaid wood materials, the heat resistance property and the thermal decomposition behavior of the consituents are discussed. The relationships between the heat resistances of the constituents is discussed and made clear by the relationship of thermal decomposition to the elemental analysis of carbonization-residue. Measurement of the evolved gas volume under various temperatures, differential thermal analyses, and the thermogravimetry of the constituents of particleboards

overlaid with graphite-phenolic sphere (GPS) were investigated.

Thermal decomposition of lauan (*Shorea sp.* : S), cured phenol-formaldehyde resin (PF), crystalline graphite (CG), and GPS terminated at 460°C, 540°C, 875°C, and 875°C, respectively, under an air-flow, while weight residues at a temperature of 1,000°C under a nitrogen flow were 24.6%, 52.4%, 93.6% and 81.3%, respectively. The weights of residues after the firing of PF, GPS, and CG were largest against lauan, that is, the carbon ratios that occupied the compostion elements. This indicates good fire resisting properties or little thermal decomposition at the evolved-gas volumes indicated by this study.

Waste wood carbonization system, T. YAMANE, T. NARISADA, A. HIROOKA, N. KATO, A. MIYAGAWA, H. YAMASAKI and S. ISHIHARA: *Proc. of the 1994 MIE International and Symposium on Global Environment and Friendly Energy Technology* 1994. MIE, Japan, pp. 294–299 (1994).

A method of making waste reusable as resources, or recycling, has been being strongly sought after. Under such circumstances, a development reported herein took up the waste wood, which is still part of valuable forest resources. More specifically, it was intended to develop a system capable of recovering high added-value charcoal and wood vinegar out of the waste wood, thereby contributing socially to the resource-saving trends. To that end, a waste wood carbonizing model plant was trial-manufactured and subjected to a series of demonstrative tests to verify its capabilities of treating waste wood, evaluate the recovered products, determine the effectiveness of natural combustion, and study the pollution control feasbility as well. Consequently, it has been proven highly probable to put the waste wood carbonizing system into successfully practicall use in the sense that it helps save energies while preventing an exhaust pollution by burning the waste wood in nature.

Carbon-based composites from bamboo charcoal and its applications, I. IDE, S. ISHIHARA, H. HIGUCHI and M. NISHIKAWA : *J. Soc. Mat. Sci. Japan,* **43**(485), 152–157 (1994) (in Japanese).

Carbonization of *Phyllostachys pubescens* Mazel ex Houzeau de Lehaile (PP) at several stages was done and the burned-charcoal (BC) obtained was used in this study. The effects of the carbonization temperature of PP on the charcoal yield, amount of charcoal element, oxidation start temperature and specific surface area were discussed.

Thermosetting charcoal spheres (CPS) were made by BC and phenol-formaldehyde resin (PF) and they were used in the manufacture of fire resistive and electromagnetic shield composites. The carbonization temperature of BC relative to fire resistivity, electro-resistivity and electromagnetic shielding properties of composites were also discussed.

The fire resistivity of the carbon composites was tested by a burn-through method and by the oxygen index method in accordance with the Japanese Industrial Standard (JIS) K 7201. Electroresistivity was tested by JIS K 6911 and electromagnetic shielding property

by a DUAL chamber method in accordance with ASTM ES 7-83. The fire resistivity and electromagnetic shielding property of the composites were improved by increasing carbonization temperature, while electroresistivity became low.

Durability of fire-retardant lauan plywood after 1, 2, 3, 7 and 15-year outdoor exposures, S. ISHIHARA: *J. Soc. Mat. Sci.,* **43**(486), 297–303 (1994) (in Japanese).

Fire-retardant plywood panels of lauam (*Shorea negrosensis* Fox) were pressure treated with a phosphoric acid containing melamine-formaldehyde condensate as a leach-resistant fire retardant and with diammonium hydrogen phosphate, guanidine phosphate, minalith and pyresote as non-leach resistant fire retardants. Their fire retarding efficiency and bending strength were measured after 1, 2, 3, 7 and 15-year outdoor exposure at the experimental field of the Wood Research Institute, Kyoto University, Uji, Kyoto.

The fire retarding efficiency and burning behaviors of the fire retardant plywood in comparison with those of the non-treated ones were evaluated while being subjected to a fire test under a high radiation furnace. The burning behaviors such as: the ignition time and time-temperature of the fire-exposed surface; the time at which the unexposed surface reached the critical temperature of 260°C; the afterflame; and the afterglow of the specimens, as indications of fire retarding efficiency, were measured. The relationships between the modulus of rupture and/or modulus of elasticity of the specimen plywood and the exposure period were also discussed.

The fire retarding efficiency of the fire retardant plywood decreased proportionately with longer exposure time. The fire retardant effectiveness of the plywood treated with inorganic fire retardants, such as diammonium hydrogen phosphate, guanidine phosphate, pyresote and minalith, was almost negligible after a year of exposure. However, the fire retardant effectiveness of those treated with phosphoric acid containing melamine-formaldehyde condensate was slightly remarkable even after seven years of outdoor exposure.

The durability of the fire retardants was in the order of pyresote, diammonium hydrogen phosphate, guanidine phosphate, minalith and phosphoric acid containing melamine-formaldehyde condensate. The percentage loss in the bending strength were 10–20%, 40–65% and 50–70% after 1, 7 and 15-year exposure period, respectively.

Improvement of the durability of wood with acryl-high-polymer VII. Biological resistance of acryl-copolymer treated wood, T. FUJIMURA, J.Y. RYU, Y. IMAMURA, T. FURUNO and S. JODAI: *Mokuzai Gakkaishi,* **39**, 1042–1048 (1993).

Wood composites with crosslinked acrylic copolymers were exposed to a brown-rot (TYP) and a white-rot fungus (COV) for investigation of their biological resistances. The values of weight losses after exposure to COV decreased remarkably with an increase in the density of crosslinking *(Dens C)* of copolymers, and reached almost nil at more than 50. A

significant correlation, however, could not be recognized between weight loss and *Dens C* when exposed to TYP. The increase of the bulking effect (*Bulking*) contributed to the improvement of decay resistance against TYP, but for COV, because of the amount of unreactional OH groups in the copolymer, wood composites with the copolymers consisting of large quantities of unreactional OH groups, in which a rapid, straight declining of weight loss was observed along with an increase in *Bulking*. The other was the composites treated with a copolymer consisting of a small amount of unreaction OH groups, in which the effects of *Bulking* on weight loss were fairly small over a wide range of values. For the latter case, the copolymers exsisting in cell lumina was assumed to contribute to the enhancement of decay resistance, being coincident with the morphological characteristics observed by scanning electron microscopy.

Improvement of the Durability of Wood with Acryl-High Polymer VIII. Measurement of polymer adsorption onto wood by piezoelectric quartz crystal, T. FUJIMURA, T. FURUNO, Y. IMAMURA and S. JODAI: *Mokuzai Gakkaishi,* **40**, 36–43 (1994).

To clarify the adsorption behavior of acrylic copolymer onto wood, wood samples were fixed on the electrode of a piezoelectric quartz crystal (PQC) by using reproduced polyethylene sheet, and the resonance frequency shifts were measured. For the measurements of the polymer adsorption by the resonance frequency shifts, the effects on the resonance frequency, which are density, viscosity, polymer concentration of the solution, and so forth are discussed. Using a correction equation, the amount of adsorption of the acrylic copolymer was calculated from the frequency shift of the PQC. The saturated amounts of adsorption of these copolymers were 17 to 40 mg/g.

Biological Resistance of Acryl-Copolymer Treated Wood II, Effect of stabilizer on biological resistance, T. FUJIMURA, J.Y. RYU, M. INOUE, Y. IMAMURA, T. FURUNO and S. JODAI: *Mokuzai Hozon (Wood Preservation),* **20**, 72–80 (1994) (in Japanese with English summary).

Wood composites with crosslinked acrylic copolymer, which includes DBT-DL (di-n-butyl tin dilaurate) as a crosslinking acceletor and stabilizer, were exposed to a brown-rot (TYP), a white-rot fungus (COV) and termite for investigation of the effects of the amount of DBT-DL on the biological resistance. The bare DBT-DL significantly affected TYP and termite as inhibitor of biodegradation but 4.994 mg of DBT-DL to 1g of wood was required for decay resistance to COV.

When DBT-DL coexisted together with crosslinking copolymers, 6.075 mg of DBT-DL to 1 g of wood was required for surpression of the attack by TYP, and the weight loss for termite attack was about 10% under the same condition. DBT-DL was assumed to reduce its toxicity against TYP and termites by the coexistance of the copolymer. The coexistance of these copolymers and DBT-DL, however, was considered to improve the safety of the

composite because of prevention of the chemical elution into water.

Chemically Modified Particleboards, H. KAJITA and Y. IMAMURA : "Recent Research on Wood and Wood-Based Materials, Current Japanese Material Research Vol. **11**", N. Shiraishi, H. Kajita and M. Norimoto, eds., p. 67–74, Elsevier Applied Science, London and New York, 1993.

Studies were carried out on chemically modified particle- and/or fiber-boards to improve their mechanical properties, dimensional stability, and biological properties. The technology developed from chemical modification of solid wood was applied to these reconstituted wood products. This report describes the production and properties of the chemically modified boars.

Estimation of the Fungal Resistance of Wood Composites for Structural Use, Y. Imamura : "Recent Research on Wood and Wood-Based Materials, Current Japanese Material Research Vol. **11**", N. Shiraishi, H. Kajita and M. Norimoto, eds., p. 75–84, Elsevier Applied Science, London and New York, 1993.

Fungal decay considerably reduces the strength of wood composite materials such as particleboards and flakeboards with only slight weight loss, so that it is not proper to estimate their fungal resistance by only using the value of weight loss as an index. A testing method that combined bending deformation and decay hazard was applied to wood-based boards to evaluate their mechanical performance under fungal attack. The rapid reduction of mechanical strength during the early stages of decay is assumed to have been due to active fungal invasion of the surface of wood elements and consequent glue failure. The structural performance of boards under biological attack is assessed in relationto the manufacturing conditions and type of treatment used as well as to the species of fungi applied. Scanning electron-microscopic observations of the fractured surfaces were conducted to present visible evidence of glue-line failures due to fungal invasion and their prevention by introducing a more adequate bonding or glue-additive treatment.

AE Monitoring Method for Detection of Decay and Termite Attacks in wood, Y. IMAMURA : *APAST (Association for Promoting Advanced Science and Technology of Forest Resources Utilization)*, No. **9**, 12–16, 1993 (in Japanese).

New technique to detect the incipient decay of wood and the feeding activities of termites using acoustic emission (AE) monitoring was reviewed. AE was detected at much lower stress levels with decay wood even in the very early stage when bended or partially compressed. AE of the burst type was also detected from wood under termite attack, and the AE event rate increased with numbers of workers present, showing the feasibility of its monitoring to nondestructively detect the feeding activities of the insects.

Preservative Treatment of Glue-Laminated Timber for Out-Door Uses, Y. IMAMURA: *Wood-Pro,* No. **22**, 19–25 1993 (in Japanese).

The characteristics of decay observed in wooden structure exposed to out-door conditions were reviewed, and the preservative treatments of glue-laminated timber were described.

Heat flow in particle mat and properties of particleboard under steam-injection pressing, T. HATA: *Wood Research,* **80**(11), 1–47 (1993).

The purpose of this study was to establish the technology for the steam-injection pressing process and to apply this technology in the production of thick low-density particleboard. The present paper consists of three chapters;

Chapter 1: The temperature behavior in particle mats during hot pressing and steam-injection pressing;

Chapter 2: The effect of particle geometry on the temperature behavior in particle mat and on the gas permeabilities in the particleboard;

Chapter 3: The effects of injection time and timing, and particle geometry on the board properties, and the trial of shortening the press cycle with steam-injection pressing.

Steam-injection pressing, T. HATA: *Mokuzai Kogyo (Wood Industry),* **49**(1), 2–7 (1994) (in Japanese).

The situation, study and the situation of steam-injection pressing technology were reviewed.

Machinery and processing systems necessary in the future for utilizing timbers from domestic plantations, H. SASAKI: Special Issue for the 30th Anniversary of the Osaka Wood Machinery Corporation, 70–73 (1993) (in Japanese).

The present state in the utilization of timbers from domestic plantations was first discussed. Then the machinery and processing systems necessary in the future for utilizing those timbers were introduced and the general tendency was discussed. Discussion was done on the machinery and processing systems regarding the structural framing materials such as glulam, LVL, Parallam, and OSL, and for the structural panels such as veneer laminates, wood composition boards and mineral-bonded particle/fiberboards.

Technology necessary in the future for processing and utilizing domestic timbers, H. SASAKI: *"Mokuzai Kakoh Saizensen" (The frontier in wood processing),* No. **1**, 2–3 (1993) (in Japanese).

Discussion was made on the way to utilize domestic timbers in the future. The technology necessary to be developed for the conversion of small-diameter logs to a high-grade structural materials was discussed.

Production of dimensionally stable medium density fiberboard by use of high-pressure steam pressing, H. OKAMOTO, S. SANO, S. KAWAI, T. OKAMOTO and H. SASAKI: *Mokuzai Gakkaishi*, **40**(4), 380–389 (1994) (in Japanese with English summary).

This study aimed to establish the production technology of dimensionally stable medium density fiberboard (MDF) with high-pressure steam pressing. The effects of high-pressure steam on the mechanical and the dimensional properties of the boards are discussed. The effects of steam treatment in the process of changes of the chemical components also are discussed. The results showed; 1) The dimensional stability of the MDF improved with increasing treatment time and steam pressure, 2) The mechanical properties of the MDF decreased with increasing treatment time and steam pressure, 3) Analyses of the changes of chemical components showed trends of decreasing hemicellulose and α-cellulose with higher steam pressures and longer treatment times, while the lignin component does not change much. The best condition of steam injection pressing time was, therefore, found to be in the range of 60–90 sec at 11 kgf/cm^2 (steam pressure) and of 90–180 sec at 6 kgf/cm^2 (steam pressure).

Isocyanate-inorganic bonded composites II. Shortening the pressing time of cement bonded particleboard, D.A. EUSEBIO, S. KAWAI, Y. IMAMURA and H. SASAKI: *Mokuzai Gakkaishi*, **39**(11), 1267–1275 (1993).

A series of experiments was conducted to determine the possibility of shortening the pressing time of cement-bonded particleboard (CBP) while simultaneously enhancing its properties. This was done by the incorporation of isocyanate (IC) resin to ordinary portland cement as a binder. CBP with IC resin (IC-CBP) and without IC resin were cold- and hot-pressed for various pressing times. For conventional CBP without IC resin, 18 h cold-pressing and 2 h hot-pressing times were necessary to produce rigid boards. The addition of IC resin resulted in boards that could be handled adequately even after a 3 h cold-pressing time, while 1 h of hot-pressing time at 60°C yielded boards with enhanced properties. A high level of bending performance was attained on IC-CBP with appropriate pressing times for both cold and hot conditions. Greater internal bond (IB) values were obtained from IC-CBP than from CBP. The IB strength values of IC-CBP improved dramatically with shorter hot-pressing times than did those of CBP. The dimensional stability of the boards also was favorably affected. Scanning electron microscopic observations revealed that cement hydration was not interfered with by the addition of IC resin but rather imparted better bonding properties.

Visiting bamboo plywood factories in China, S. KAWAI: *Mokuzai Kogyou (Wood Industry)*, **49**(2), 90–92 (1994) (in Japanese).

The present state of bamboo plywood industry in China is described. The process, the properties, and the utilization of bamboo plywood were briefly explained.

Laminated veneer lumber and composite beams produced from tropical hardwood thinnings, H. SASAKI, Q. WANG, S. KAWAI and R.A. KADER : "Recent Research on Wood and Wood-Based Materials, Current Japanese Material Research Vol. **11**", N. Shiraishi, H. Kajita and M. Norimoto eds., p. 55–66, Elsevier Applied Science, London and New York, 1993.

The mechancial properties of laminated veneer lumber (LVL) made from plantation thinnings (9-year old) grown in Sabah, Malaysia were investigated. The species used were *Acacia mangium* (AM), *Gmelina arborea* (GA), *Albizia falcata* (AF) and *Eucalyptus deglupta* (ED). Laminated veneer lumber (LVL) was made up of 9-ply veneers of 2.5 mm thickness from each species, using staggered scarf joints for the veneers. Composite beams were constructed with LVL flanges and a low-density semi-strand board (LDB) web, and the mechanical properties were tested.

The average standard deviation in modulus of elasticity (MOE) of LVL was $1/\sqrt{n}$ (where n is the ply number) of that of solid sawn lumber of the same species.

The modulus of rupture (MOR) of LVL was almost the same as that of solid sawn lumber, and the reduction in the variation of MOR was not as that found with MOE.

MOE and MOR for the composite beam were lower than the figures for LVL, but much higher than those for LDB. The variation in these properties was a little less than that of LVL, so that the composite beam tested is potentially useful as a structural member.

With the short-span bending test specimens, shearing failure occurred near the glue layer between the flange and web. The criteria derived for the onset of bending or shear failure were useful for predicting the failure pattern.

Low-density particleboard, S. KAWAI and H. SASAKI : "Recent Research on Wood and Wood-Based Materials, Current Japanese Materials Research Vol. **11**", N. Shiraishi, H. Kajita and M. Norimoto eds., p. 33–42, Elsevier Applied Science, London and New York, 1993.

Dimensionally stable low-density (0.4–0.6 g/cm^3) particleboard is required as a substitute for plywood panels. This paper discusses the limit for lowering the density of particleboards by using isocyanate resins and the effects of various factors such as the species (density) and configuration of the particles, the resin content and resin components on the properties of low-density particleboard.

The mechanical properties of boards from different species had linear relationships with the compaction ratio (the board density divided by raw material density), and the practical lower limit of the compaction ratio was found to be 0.7–0.8 for isocyanate resin. The thickness swelling of the boards was independent of the species of raw material, and increased with increasing compaction ratio, i.e., low-density (low-compaction) particleboards were more dimensionally stable. Linear relationships between the mechanical

properties and shape factors based on the particle configuration and derived from fracture mechanics theory were observed. Both the mechanical and dimensional properties of the boards improved with increasing resin content, but were generally independent of the formulation of isocyanate compound adhesives such as the free-isocyanate group content and functionality of crude methylene diphenyl diisocyanate (MDI). Crude MDI alone, compound resin, and unreacted mixed resin did not make much difference in the board properties either.

Steam-injection pressing technology, H. SASAKI, S. KAWAI, T. HATA and B. SUBIYANTO: "Recent Research on Wood and Wood-Based Materials, Current Japanese Materials Research Vol. **11**", N. Shiraishi, H. Kajita and M. Norimoto eds., p. 43–54, Elsevier Applied Science, London and New York, 1993.

In order to establish the optimum steam-injection pressing technology, the characteristics of curing adhesives under high steam pressure, the temperature behavior in the particle mat core during steam-injection pressing, and the length of pressing time were investigated. A semi-continuous steam-injection press of test-plant scale was then developed and applied to the production of thick, low-density particleboard.

The duration and pressure of steam injection with urea formaldehyde (UF) and urea-melamine formaldehyde (UMF) adhesives needed to be carefully determined for particleboard production by high-temperature steam-injection pressing, too-high steam temperatures resulting in a poor internal bond strength. On the other hand, the internal bond strength of those boards bonded with other resins was not perceptibly influenced by the steam temperature.

The temperature in the middle layer of a particle mat with a thickness of 20 or 40 mm reached more than 100°C at the moment of steam injection, whereas it takes 4 and 11 minutes, respectively, in the case of hot pressing. The computer simulation predicts that only a few seconds of steam injection is required for a mat thickness within 100 mm to reach 100°C in the mat core.

Isocyanate bonded particleboards with a thickness of 20 mm could be produced with a press time of around one minute. This corresponds to only about one-fifth of the press time of a conventional hot-platen press, and this effect of steam-injection pressing on shortening the press time would be greater for thicker board production.

The newly developed semi-continuous, steam-injection press worked satisfactorily, and 100 mm thick low-density particleboards bonded with an isocyanate resin could be manufactured with a 90-second press cycle.